

THE ANATOMY OF TWO BRAZILIAN LAND SHELLS, *ANOSTOMA*
DEPRESSUM AND *TOMIGERUS CLAUSUS*.

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Among the many strange species of Brazilian land shells, those belonging to the genus *Anostoma* and *Tomigerus* present the most unusual characters. In the first named the last whorl of the shell is "straightened, turning toward the margin and upward" (Pilsbry¹), so that the visceral mass is carried upside down. Pilsbry has suggested that, judging by the growth lines, the shell is carried at first with the equatorial plane nearly vertical, and that as the last whorl is being added the animal falls to the right, thus undergoing a twisting process which brings the spire of the shell into a reversed position. Unfortunately, no young, living individuals were secured by the Stanford Expedition, but in the shell (Pl. XXXI, figs. 2, 4) of one immature specimen the free borders are highly angular, and if held in an upright position, as Pilsbry suggests, would offer the least possible resistance in moving about through the grassy regions where these snails abound.

The specimens of *Anostoma* on which this paper is based were found in the low hilly country in the neighborhood of Baixa Verde, a small settlement between 40 and 50 kilometers to the northwest of Natal. A fire had swept the region in comparatively recent times, and fragments of shells were everywhere abundant in the scrubby underbrush of the rocky hills. Extended search brought to light a single living individual in a profound state of aestivation, which a prolonged stay in a moist chamber failed to terminate. In addition, five dead shells were discovered in a heap of stones, and were measured and described in the field. According to my notes made at the time, they vary in greatest diameter from 33 to 37 mm.; in lesser diameter from 24.5 to 28.5 mm.; and in altitude from 16 to 17.5 mm. Also in regard to the number and position of the apertural teeth or lamellæ there is considerable variation. In two specimens there are seven, two of them being parietal; in another there are likewise two parietal folds, but the columellar lamella is absent; in the remaining two there are three parietal folds, the middle one curving behind the

¹ *Manual of Conchology*, Vol. XIV.

angle lamella as in *A. octodentatum*, while of the lip teeth the columellar fold is lacking entirely in one specimen, and is almost completely obsolete in the other. Where the color persisted, the peristome was pinkish-brown or flesh tinted and characteristic of the species. The immature shell measures 21 by 18 mm. in width, with an altitude of 10.5 mm.; the axis is hollow and the mouth possesses no lamellæ.

After the living specimen had been decalcified and sketched (Pl. XXXI, fig. 3), it was stained and sectioned, all the study of the various systems being made from reconstructions. The head region was highly contracted, and was not examined to any considerable extent. The unusual length of the mantle cavity, extending from the pericardium to the external pore, is reflected in the great length of the mantle arteries and veins, as well as that of the ureter and portions of the reproductive system. Otherwise there are no especially noteworthy features beyond what are indicated in the figures.

The kidney, placed between the pericardial and body walls on the anterior face of the last fold, presents the usual sac-like appearance. Evidently the reno-pericardial opening is minute, if it exists at all, for a careful study of sections failed to disclose its whereabouts. The ureter, likewise, is difficult to trace throughout a portion of its course. Its external opening is immediately behind that of the alimentary canal, and from this point is readily followed to the region of the pericardium, where it decreases in caliber and passes into a network of blood vessels. Furthermore, the present specimen was slightly damaged in the region of the columellar muscle, thus adding to the difficulty of tracing the connections. It appears that the kidney is in contact, along its inner face, with a slender sack or tube with which the ureter communicates.

The digestive system (Pl. XXXI, fig. 6) requires no especial description. A highly intelligent native lad of Baixa Verde is responsible for the statement that *Anostoma* lives solely on vegetable matter; at all events, several specimens, that he kept for several months, thrived on garden vegetables and moss. He had made no observations on the position of the body in young individuals.

The description of the reproductive system of *A. ringens*, as described by Fischer,² applies in all essential details to *A. depressum*, with the exception of a penis retractor muscle attached to the vas deferens. In *A. depressum* the external reproductive pore, located

² *Jour. de Conchyl.*, 1869, p. 261.

on the right side of the head, leads into a small atrium with which the penis, hermaphroditic duct, and seminal receptacle attach. The first named is a heavy, muscular organ, accompanied by the usual slender vas deferens, their union being effected at some distance from the distal end of the penis, which thus forms a flagellum (Pl. XXXI, fig. 7, f). As the flagellum thus holds identically the same position as the so-called penis retractor in *A. ringens*, I am strongly inclined to the opinion that we are actually dealing with flagella in both instances. In the present specimen the penis and flagellum are both sharply defined and appear to be without muscular attachments, though bound to the body wall by delicate connective tissue strands. In the neighborhood of the outer opening, however, the penis sheath affords attachment for three or four slender muscle bands that I am inclined to regard as penis retractors.

The hermaphroditic duct, a highly glandular duct of comparatively even diameter, traverses the greater portion of the first coil of the body to enter the accessory glands. All of these structures are in a quiescent condition, and in size and configuration probably fall far short of their fully developed state in the sexually mature condition. The same is likewise true of the gonad. While the duct leading to it from the accessory glands is clearly apparent throughout the first part of its course, it gradually approaches the vanishing point, and cannot with certainty be traced to a gonad, which is accordingly drawn in its hypothetical position.

Two living specimens of *Tomigerus clausus* were found beneath stones in the vicinity of Cara-Mirim, a town about midway between Baixa Verde and Natal. Both were in a state of aestivation, and failed to revive, though kept in a moist chamber for several days. It is evident from several features of the shell and internal organization that the shell in this genus is carried with its principal axis transverse to the longitudinal axis of the foot; that is, the spire is directed to the right. The flattened surface of the outer whorl thus rests upon the dorsal surface of the foot or upon the substratum when the animal is in a state of aestivation, a position which they had assumed in both instances.

As each individual was in a highly contracted state, with foot and head drawn far within the shell, external features are difficult to determine. It appears certain, however, that the mantle, with more highly thickened margins and more glandular epithelium than in *Anostoma*, extends throughout the first whorl of the shell to the region adjacent to the aperture. It thus terminates at the point

where the ureter (Pl. XXXI, fig. 5, u) bends abruptly upon itself. The external openings of the ureter and intestine occupy the usual positions on the right side, and from this point pursue a course parallel to the external surface of the body in close contact with the mantle cavity. As noted previously, the ureter bends sharply upon itself at the termination of the mantle cavity, and, dorsally placed with reference to this chamber, proceeds anteriorly to unite with the forward extremity of the kidney. This last-named body is a compact, sac-like body consisting, as usual, of highly folded glandular epithelium confined, in the posterior half of the organ, to the outer face. As may be seen in the diagram (Pl. XXXI fig. 5), the pericardium (p) is in contact with this glandular section throughout its entire length, but is scarcely more than half as extensive. The reno-pericardial opening was not observed. It may be added that the kidney is placed dorsally with reference to the pericardium.

The reproductive system, considering that the gonad is in a highly quiescent state, is comparatively large and more compact than in *Anostoma*. The gonad consists of several slender diverticula (probably three times as many as are indicated in Pl. XXXI, fig. 1), located in the apical whorls of the visceral mass. These contain primitive sex cells undifferentiated into sperms and ova. The hermaphroditic duct extends ventrally, close to the columella, and shortly before entering the accessory glands attaches to a slender pear-shaped organ, possibly a seminal vesicle, consisting of upwards of ten small diverticula imbedded in a muscular sheath. These are empty and give no sign of glandular activity. The accessory glands are voluminous, though inactive organs, whose general extent is indicated in Pl. XXXI, fig. 1, ag, though several lobes give them a much greater dorso-ventral thickness than can be shown in the figure. The duct leading from the accessory glands becomes considerably widened near its proximal extremity, and possibly functions as a shell gland. As in *Anostoma*, the duct from the seminal receptacle springs from this point, and, as a slender canal, proceeds to the spacious sack situated in close proximity to the accessory glands. The vas deferens, likewise, unites with the penis some distance from its distal extremity, thus forming a flagellum (Pl. XXXI, fig. 1). No penis retractor has been discovered in this region. On the other hand, several strands attaching to the penis sheath in the neighborhood of the outer opening may operate as retractors.

The digestive system is sufficiently illustrated (Pl. XXXI, fig. 5) to require no further explanation beyond the statement that three distinct bile ducts open into the stomach.

EXPLANATION OF PLATE XXXI.

- Fig. 1.—Reproductive system of *Tomigerus clausus*, dorsal view. ag, accessory glands; f, flagellum; g, gonad; r, seminal receptacle; v, seminal vesicle.
- Fig. 2.—Shell of young *Anostoma depressum*.
- Fig. 3.—Heart and kidney (k) of *A. depressum*, viewed from underside of spire.
- Fig. 4.—Shell of young *A. depressum*.
- Fig. 5.—Dorsal view of digestive tract, kidney (k), and pericardium (p) of *Tomigerus clausus*. Contracted specimen.
- Fig. 6.—Digestive tract of *A. depressum* viewed from apex of spire.
- Fig. 7.—Reproductive system of *A. depressum* viewed from apex of shell. ag, accessory glands; f, flagellum; g, gonad; r, seminal receptacle.